Multi-Modality Integration

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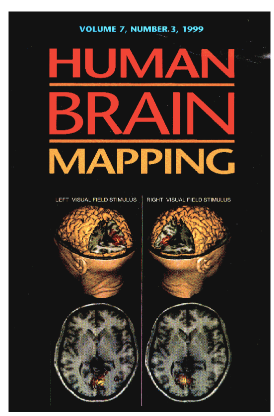
Background (review)

Spatial Bayesian Inference analysis published in Human Brain Mapping, vol 7, p. 195, 1999.

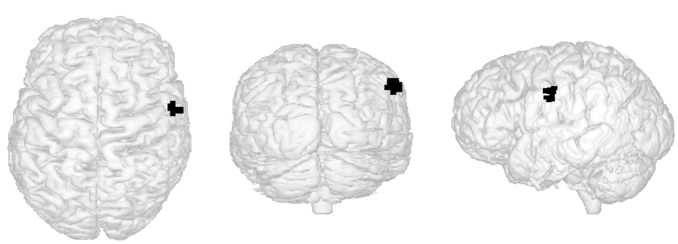


Bayesian inference

- Formal use of prior information.
- Results in a posterior probability distribution.
- Use Markov Chain Monte Carlo to numerically generate samples from the posterior distribution.
- All inferences are drawn from the (numerically sampled) posterior probability distribution.

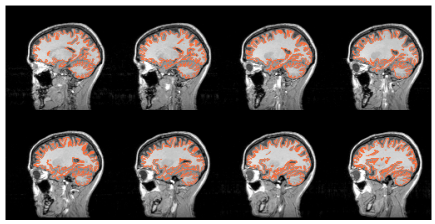
Example with simulated data

- Active region used to generate simulate data.



Prior information

- Anatomical location and orientation information from MRI.
- Neural activity limited to a variable number of variable size active regions, defined by tagged cortical voxels within a bounding sphere.



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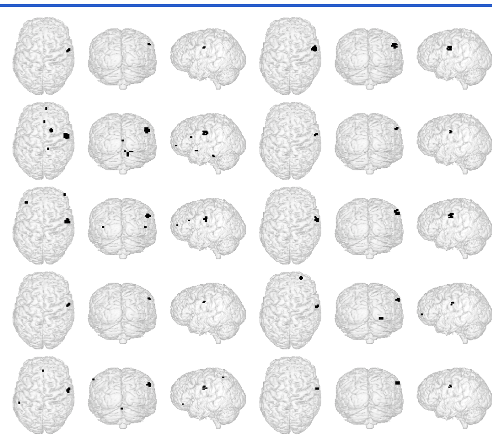
Results from Spatial Analysis



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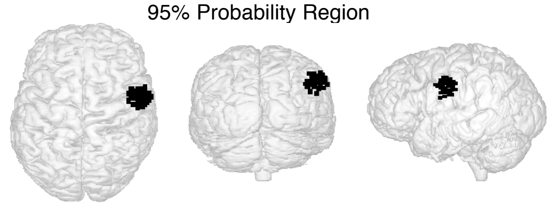
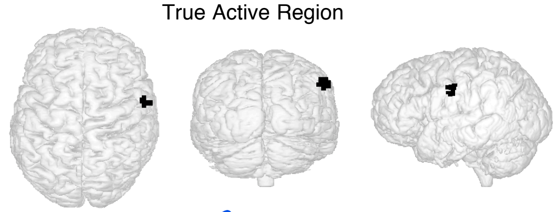
Results from Spatial Analysis

95% Probability Region



True Active Region



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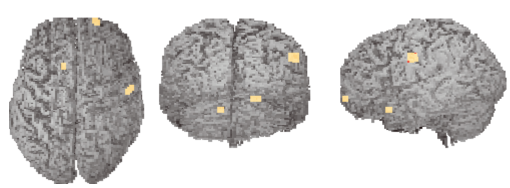
Results from Spatial Analysis (continued)

Most Likely Result



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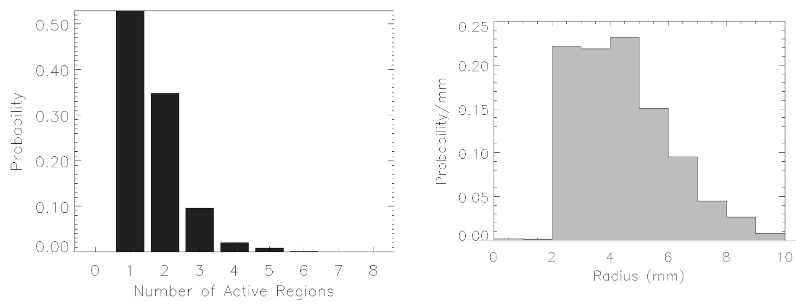
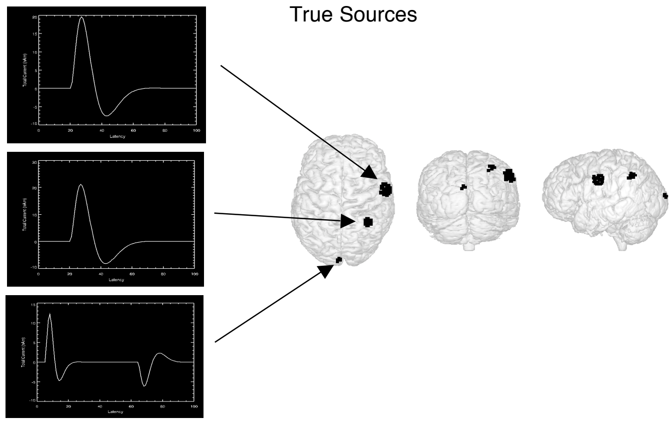
Results from Spatial Analysis (continued)



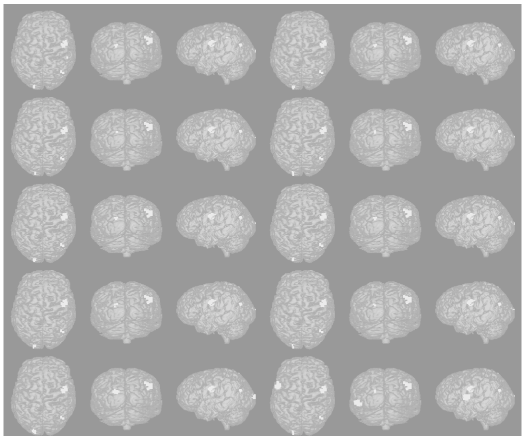
Extension to temporal domain

- **Sources have a temporal extent.**
- **Temporal correlation as prior information.**
- **Increase in information results in more rugged posterior distribution.**

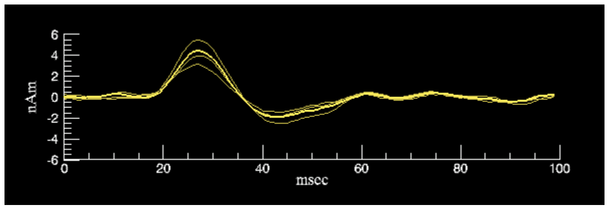
Example from Simulated Data



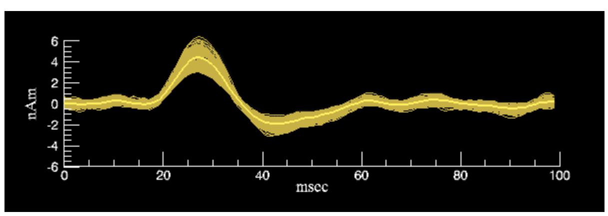
Sample Active Regions



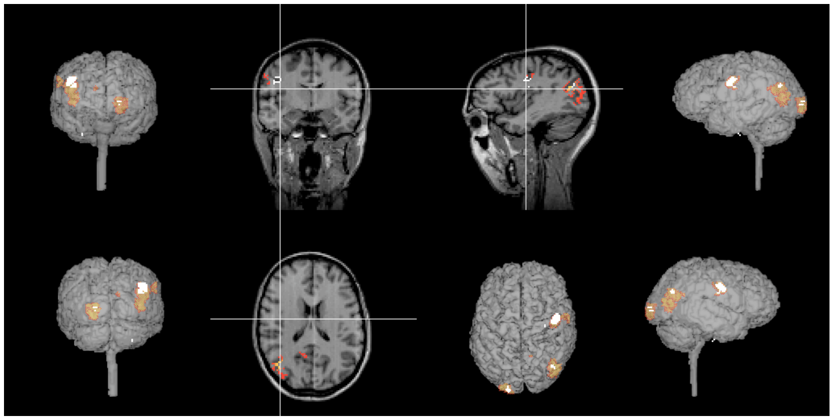
Sample Time-Courses for Anterior Region



Distribution of Time-Courses



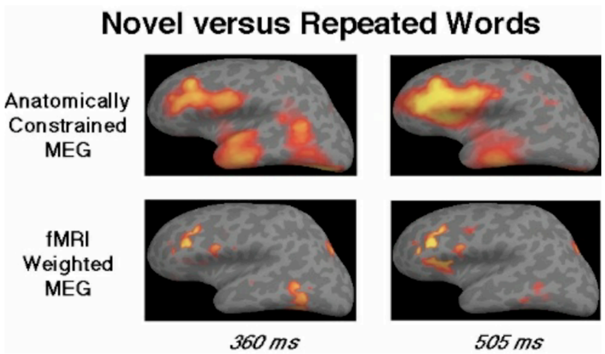
Results in spatial and anatomical domains



Integration with fMRI

Other integration strategies

- MGH: fMRI weighted MEG linear inverse.



Multi-Scale Modeling

David Schmidt (P-21) Balu Nadiga (CCS-2) David Sharp (T-13)

- In non-linear systems, small scale dynamics affect large scale behavior.
- Computer simulations of a system over a large domain (e.g. ocean) require a very large grid to resolve small scale phenomenon (e.g. eddies).
- Often a coarser grid, that does not resolve the small scale phenomenon, is used in order for the simulation to run in a reasonable period of time.
- The differential equations to be simulated are then modified to try to mimic the effects of the unresolved sub-grid phenomenon.

Closure

- Original equation to be integrated

$$\partial q/\partial t = F(q)$$

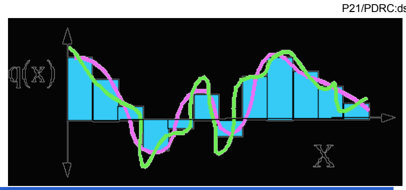
- Effect of fields on a grid

$$\partial \overline{q}/\partial t \neq F(\overline{q})$$

- Modify equations such that

$$\widetilde{F}(\overline{q}) \sim \overline{F(q)}$$

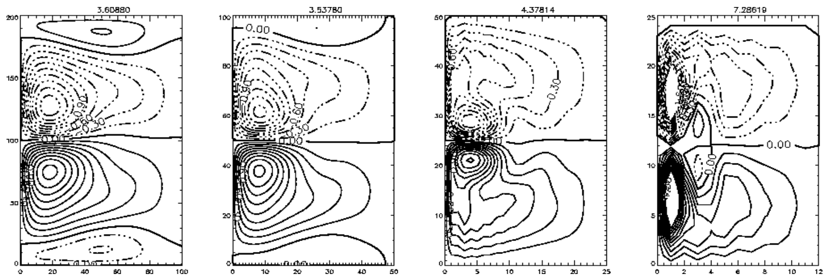
Stochastic closure



- There are many different continuous fields (q(x)) that could have produced a given field on a grid (blue bar graph).
- There should be a distribution of closure relations $P[\widetilde{F}(\overline{q})]$ from which elements are drawn at random as the system is being simulated over time.
- This distribution may be found by simulating the system on a fine grid, that resolves the small scale phenomenon, but on a small domain.

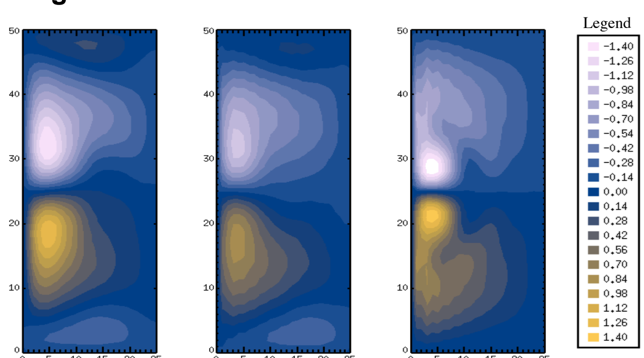
Example: simple basin model with uniform wind forcing

- Effects of grid size on time-averaged stream function.



Results from stochastic closure run

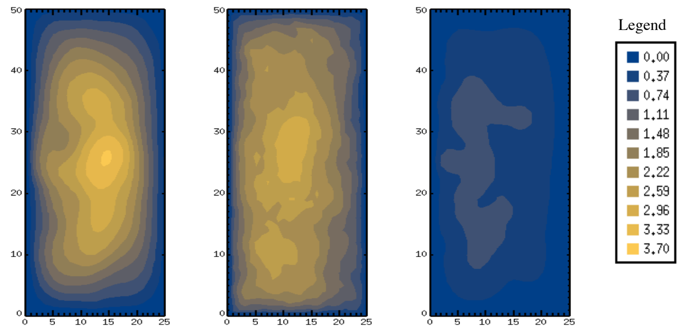
- Average stream function



Fine grid Stochastic Coarse grid Coarse grid

Results from stochastic closure run

- Temporal variability (standard deviation) of stream function



Fine grid   Stochastic coarse grid   Coarse grid

Stochastic closure summary

- Small-scale phenomenon are treated stochastically.
- Exact temporal ordering is lost but time-averaged quantities (even multiple moments) are retained.
- Well-suited for uncertainty quantification.